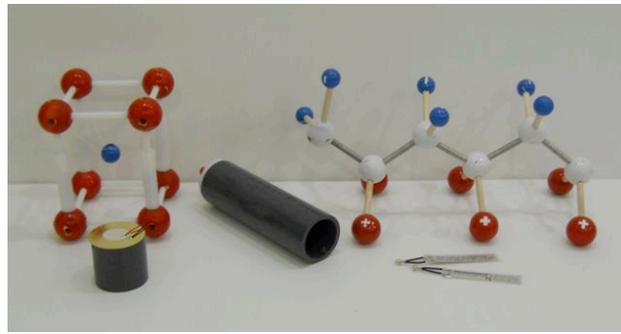


GOAL:

Visitors will understand that some materials produce electricity when bent or deformed, because it causes an asymmetry in the charge of the material.

MATERIALS:

- Flicker with neon bulb
- PVDF model
- LED piezoelectric transducer
- Crystal model
- Grounded grill starter



PROCEDURE:

Set-up:

1. Lay out all supplies.

Doing the demonstration:

1. Explain that piezoelectricity is a way of creating electricity using the special properties of some materials. These materials have the ability to convert mechanical energy (produced by physical force) into electrical energy. Show visitors the flicker. Ask a volunteer to inspect it for batteries or other obvious electrical plugs. When they don't find any, have them shake the flicker to see the small neon bulb light up. Explain that they created electricity by changing the shape of the material.
2. Introduce the PVDF model as a zoomed-in version of the flicker. Hold it vertically and explain that the blue atoms are negatively charged, and the red atoms are positively charged. Point out that the charges are symmetrically positioned, which means that the molecule is electrically balanced and neutral. Have a visitor bend the model, and notice that the charges become asymmetrically positioned, which causes unbalance in the distribution of the electrical charge and therefore produces electricity.
3. Next, bring out the transducer. Ask a visitor to tap on, or flick, the transducer with their finger and look at the LED inside as it lights up. Explain that they are again changing the shape of the material as they tap, even though the change is too small to see.
4. Show visitors the crystal model. Point out that the blue negative charge is symmetrically oriented in the resting state. Ask a visitor to push down on the model, just as they tapped the transducer, and ask them to observe the location of the blue atom. When deformed, the charge in the crystal is more negative on one side than the other, producing electricity.



5. Finally, bring out the grill starter to show visitors and explain that it is a common application of piezoelectricity. Demonstrate the spark it can make (1000 volts).

Clean-up:

1. Gather all materials and return to storage.

EXPLANATION:

Materials that are piezoelectric produce an electrical charge when they are mechanically stressed. The specific phenomenon depends on the type of piezoelectric material. The neon bulb flicker is made of a material called polyvinylidene fluoride (PVDF). Substances like PVDF have to be polarized in order to show the piezoelectric phenomenon, so that when the plastic is bent, there is an asymmetry between the positively charged side and the negatively charged side. When there is an asymmetry of electric charges, a voltage difference is created across the material, which can then push charges through a circuit.

Substances like quartz and certain piezoelectric ceramics work slightly differently. These materials are crystalline in nature, and have charged particles (atoms) arranged symmetrically throughout their crystal structure. When stress is applied to the structure, the charged particles shift to one side, away from these symmetrical positions. This shift causes an asymmetry of charges, which results in a voltage. Even though it is a slightly different mechanism for creating the asymmetry, it is still this asymmetry that creates the voltage. The flicker generates 90 volts of electricity, whereas the transducer generates ~2 volts of electricity.

There is a wide range of applications for piezoelectric materials. For instance, NASA sent the New Horizons probe out towards Pluto with a piezoelectric sheet attached, which is attached to a computer. When meteorites and space dust hit the sheet, the computer will be able to tell how big they are and how fast they were going, based on the electrical charge created by the impact. Closer to home, most gas grills use a piezoelectric grill starter. Despite its small size, the starter can generate thousands of volts – which is enough to create a large spark. There has also been some work done on making backpacks, shoes, and vehicle suspensions that can act as personal energy harvesters by using piezoelectric materials, in order to power personal electronic devices like iPods or cell phones or to improve the range of motor vehicles that move over bumpy terrain.

WHAT COULD GO WRONG?

Do **not** allow guests to use the grounded grill starter, as it can deliver a nasty shock. You may have to push down hard on the starter button to make it spark.

The transducer requires a sharp, but not overly strong, tap or flick to light the bulb. Hitting it with any kind of instrument will likely damage the transducer.

GENERAL MAINTENANCE:

Handle the transducers carefully, as the connections are a bit fragile.